# Specifications for an Atomic Layer Deposition System

**Scope:** This specification describes the minimum technical requirements and the minimum acceptable performance standards for an Atomic Layer Deposition System (ALD) to be installed by the contractor at the Naval Research Laboratory (NRL), Washington, DC. The ALD system will provide ease of operation and safety to the users of this system.

**Description:** The ALD system shall be configured for Thermal and Plasma-enhanced ALD deposition of metals, metal oxides and nitrides. The ALD system shall be provided with one hot source (up to 300$^{o}$ C) and one hot source (up to 500°C) as well as a remote RF plasma source for Plasma ALD processing. In addition to providing access to a much broader range of process chemistries and materials deposited, the remote plasma source shall also be capable of use for pre or post-treatment of the substrate surface.

**Atomic Layer Deposition System**
**CLIN 0001**

1. The system shall provide flexibility for research requirements and consist of a modular structure in which precursors can be easily changed.

2. The system shall provide a computer-controlled system with installed software and licenses for user login, operator interface of process control, data logging, and recipe management.

3. The ALD system will include a carrier gas line, minimum of 2 gas flow controllers, at least 2 gas lines for thermal ALD, at least 4 gas lines for plasma ALD, at least 3 liquid sources, at least 2 hot sources, one pressure transducer for hot source pulse monitoring and one pressure transducer for liquid source pulse monitoring.

4. The ALD system will include a precursor trap and precursor deactivation unit.

5. The system shall provide a remote plasma reaction chamber with a 13.56MHz 300W RF Generator and automatic matching unit, plasma gas feeding connections and a gate valve.

6. The ALD system will have a load-lock capable of loading wafers of at least 200mm in diameter. The load lock will have a view port and pressure transducer, a manipulator and inert gas and vacuum feeder lines with valves. The load lock shall be provided with a turbo-molecular pump backed by a rotary vacuum pump suitable for oxygen service (Fomblin fluid) and oil filtration unit for the rotary vacuum pump.

7. The ALD system must include one hot source up to 300$^{o}$ C and one hot source up to 500°C.

8. The ALD system must be capable of Ag metal deposition via the radical-enhanced plasma ALD process.

9. The system must include a ventilation cabinet.

10. The ALD system will include a chiller for cooling water circulation.

11. The system will include a transformer to allow operations at 220-240V, 3 phase, 60 Hz.

12. The manufacturer shall provide access to their existing process library as well as processes developed in the future. The manufacturer shall provide interactive process development support through conventional media. In addition, the manufacturer shall provide experimental evidence of plasma process results as well as proof of any guaranteed processes licensed through the ASM with the response.

13. The Contractor shall provide a Certificate of Compliance guaranteeing that all the requirements of this specification have been met.

14. System performance shall be measured by test depositions of:

    $Al_2O_3$ deposited at 300ºC via thermal process with refractive index >1.66
    $Al_2O_3$ deposited at 200ºC via $O_2$ plasma process with refractive index >1.66
    $HfO_2$ with refractive index ~ 2.07
    Ag deposited via Radical-Enhanced plasma process of 5nm and 10 nm thickness
    ZnO deposited at 200ºC with refractive index >1.98
    AlN deposited at 200ºC via $NH_3$ plasma process with refractive index ~ 1.9

    Films shall be deposited with typical film thickness uniformity <±2% 4” via the plasma process. Thermally deposited films shall have typical uniformities of <±2% for all wafer sizes.

**Installation / Training**
**CLIN 0002**

1. The system will be installed in Code 6876 in a Class 10,000 laboratory at the Naval Research Laboratory, Washington DC 20375.

2. The manufacturer shall provide system commissioning, operator training and process verification which shall be conducted by a factory trained Field Service Technician and/or a Process Engineer.

3. Training will be required for an anticipated 5 people. Training will be conducted at the Naval Research Laboratory for a minimum of 2 full days.

**Warranty**
**CLIN 0003**

The system shall be provided with a 1-year factory warranty that covers all parts, labor and travel expenses for on-site support of the equipment. The warranty period shall begin on the date of system acceptance. In addition, the Contractor shall register all equipment requiring separate warranty by other manufacturers; such warranties shall also be effective from the date of system acceptance

**Operation/Maintenance Manuals**
**CLIN 0004**

The system shall be shipped with one (1) complete set of operation and maintenance manuals printed on plain paper as well as an electronic version in PDF format.

**Optional Items**

Optional Items are to be priced separately. The Government may require the delivery of the optional item(s) at time of delivery of CLIN 0001 or up to six months thereafter.

**Precursor Delivery Module**
**CLIN 0006 (Option 1)**

One additional Precursor Delivery Module with heated lines and ALD valve. The Precursor Delivery Module must have sufficiently heated lines to prevent it from condensing, and an ALD valve is required to control flow.

**Mass Flow Controller**
**CLIN 0007 (Option 2)**

One additional Mass Flow Controller (MFC) gas line for thermal ALD processes. The gas lines must be sufficiently heated to prevent the precursor gas from condensing. A Mass Flow Controller is required to control flow.

**Ozone Source**
**CLIN 0008 (Option 3)**

An ozone source that produces a sufficient quantity to clean or modify a substrate. Ozone source should be able capable to use for plasma assisted growth.